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FLIGHT EVALUATION OF SHORT BROTHERS AND HARLAND LIMITED SC7 MILITARY SKYVAN-SERIES 3M



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Equipment Development and Test Report 5700-11

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FLIGHT EVALUATION
OF
SHORT BROTHERS AND HARLAND LIMITED
SC7 MILITARY SKYVAN - SERIES 3M

by
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ABSTRACT

A limited-handling-qualities evaluation was conducted on the Short Brothers and Harland Limited SC7 Military Skyvan Series 3M at Edwards Air Force Base. On September 24, 1971 the U.S. Army Aviation Systems Test Activity performed the flight tests, which included an evaluation of the cockpit, ground operation, short field and normal takeoff and landing, steep dives, steep turns, engine operation, stability, stalls, trim controls, and single engine operation. Gross weight was 12,000 lb, although normal sea level maximum is 13,500 lb. Payload may vary from 3000 to 5000 lb, depending on fuel load. Carrying capacity was adequate for 12 smokejumpers. The cargo compartment has a 6 ft x 6 ft rear-facing door that can be opened during flight. Except for the oversensitive power brakes and a difficulty in maintaining the exhaust-gas temperature during high power output, performance was satisfactory. The Skyvan meets the performance requirements typically associated with Forest Service missions involving smokejumping, paracargo, freight, and unimproved airstrip operations.



Short Brothers & Harland SC7 Military Skyvan.

A report on ED&T Project No. 1906 - Flight
Evaluation of SC7 Military Skyvan - sponsored by the Division of Fire Management.

INTRODUCTION

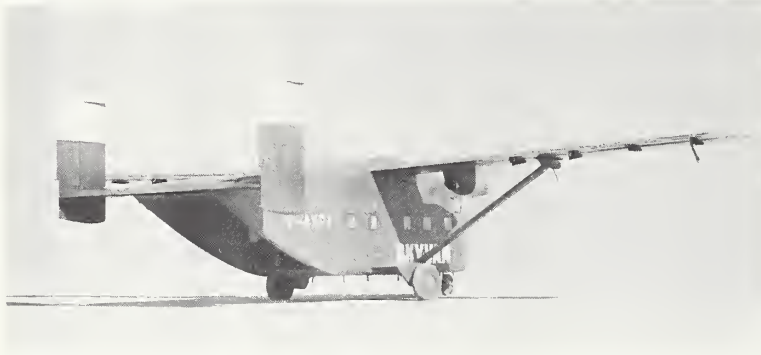
This report covers a flight test of the SC7 Military Skyvan Series 3M manufactured by Short Brothers and Harland Limited, Queen's Island, Belfast, Ireland. On September 20, 1971 a request was made to the U.S. Army Aviation Systems Test Activity (USAASTA) at Edwards Air Force Base by the San Dimas Equipment Development Center for a flight test of the Skyvan and a report of the results. Test objectives were to conduct a limited-handling-qualities evaluation and to note performance characteristics during selected maneuvers. Test flights were made in the vicinity of Edwards AFB on September 24, 1971.

The resulting pilot's "point of view" is appropriate as a companion study to the tests made at the Missoula Equipment Development Center (MEDC) on September 13-17, 1971, when the Skyvan was evaluated for smokejumping and paracargo operations. Tests were conducted by MEDC with personnel from San Dimas Equipment Development Center (SDEDC) and several Forest Service Regions participating. The military configuration was determined to be best suited for Forest Service use. The military Skyvan tested at Missoula was the same aircraft (G-AXPT) flown at Edwards AFB. Flight test information that follows was abstracted from the USAASTA report (Limited Evaluation of the Short SC7 Skyvan Series 3M) dated January 4, 1972. Personnel conducting the evaluation, including the pilots, were from USAASTA and Short Brothers and Harland Limited.

An additional flight evaluation of the military Skyvan was performed by the Air Force at Edwards Air Force Base during July of 1969. The published report is numbered FTC-TR-69-34 and is entitled "Flight Evaluation of Short SC7 Military Skyvan Series 3M." Excerpts from this technical report are included in Appendix A and C.

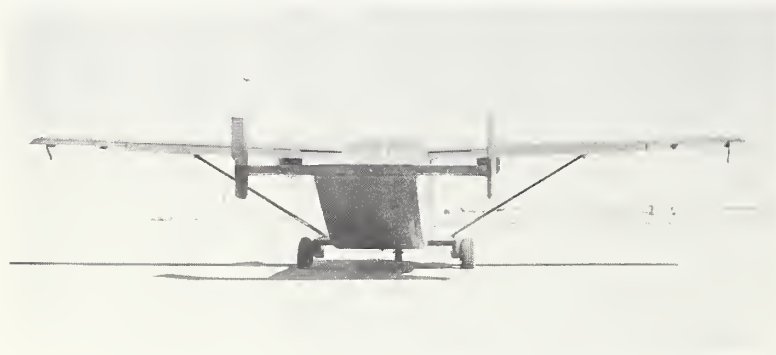
DESCRIPTION OF AIRCRAFT

The Skyvan is an all metal, high wing aircraft with a fixed tricycle landing gear. It is powered by two Garrett AiResearch TPE 331-2-201A turboprop engines developing 715 shaft horsepower each. Propellers are Hartzell three-bladed, constant



Rear opening cargo door as it would appear in flight.

Cargo door with step lowered for loading.



Cargo door closed.

speed, full feathering, and reversible. Maximum gross weight for takeoff at sea level on a standard day is 13,500 lb. Cargo capacity varies from 3000 to 5000 lb, depending on the amount of fuel carried. The aircraft can carry up to 12 fully

equipped smokejumpers. It also has an inward opening, one-piece rear-loading door that can be opened during flight. The approximate dimensions of this opening are 6 x 6 ft.



Crew access door and hinged nose section.

Rear cargo door from pilot's view.



The aircraft has dual controls and is equipped for instrument flight. The flight control system is mechanical, with no artificial feel devices. Brakes, power steering, and flaps are hydraulically operated. (See Appendix A, Exterior Dimensions.)

INSTRUMENTATION

Factory-installed standard cockpit instruments were the source of quantitative data. Other instruments, not part of the cockpit installation, were hand-held. An example of a hand-held instrument is the device that measured the force applied to or exerted by the control column during a flight maneuver.

TEST PROCEDURE

Evaluation flights at Fox Field, Lancaster, and Edwards AFB were conducted as a joint effort by personnel from the U.S. Army Aviation Systems Test Activity and Short Brothers and Harland Limited. Four flights totaling 4 hours were made. Take-off gross weight was 12,000 lb, with the center of gravity near the midpoint between its fore and aft limits. Flight altitudes varied from 2000- to 8000-ft pressure altitude. Flight and ground maneuvers were executed so that operation limitations, as provided by the manufacturer, were not exceeded.

Test pilots rated each maneuver in terms of its performance characteristics and the demands of the pilot. Ratings were based on the Handling Qualities Rating Scale (HQRS) used by the U.S. Army Test Activity (see Appendix B). In general, all qualities tested except one were placed in the next to the highest rating bracket (HQRS-2) which is defined as follows: "Aircraft characteristics are good with negligible deficiencies; and pilot compensation is not a factor for desired performance of the required operation." The exception has to do with exhaust gas temperature and is discussed under Engine Operation in the Results section of this report.

RESULTS

General

As far as handling qualities are concerned, the Skyvan exhibited no deficiencies that would restrict or limit its ability to perform Forest Service cargo and smoke-jumper missions. Performance characteristics were satisfactory. Two shortcomings were noted: difficulty in maintaining exhaust gas temperature (EGT) within desired limits, and oversensitive power brakes.

Selected Maneuvers

To test performance and maneuverability, the Short Brothers and Harland test pilots flew the following maneuvers, using conventional control techniques:

Short field takeoff and landing;

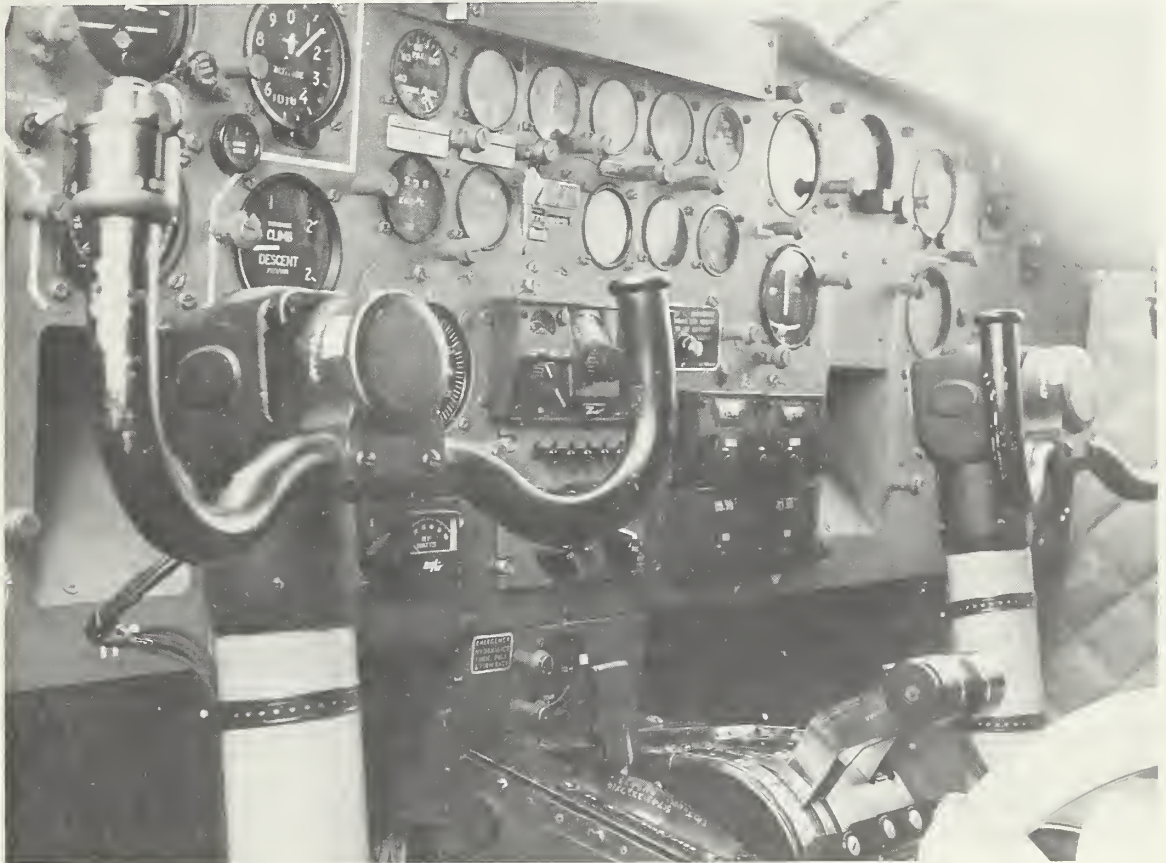
Normal takeoff and landing;

Steep dive angle;

Steep turns.

Cockpit

Outward visibility, from either pilot or copilot seat during flight and taxi, was excellent. Seat adjustments were adequate. The center pedestal contained engine and propeller controls, trim wheels, and flap and gear handles. The flight-control gust-lock handle was designed so that the fuel could not be turned on until the controls were unlocked. The layout of instrumentation and system controls in the cockpit permitted the aircraft to be flown comfortably from the left seat by a single pilot. Noise level during ground and flight activity was not excessive, and the protection afforded by a headset was adequate for extended operations.



Instrument panel and flight controls.

Ground Handling

Because of the excellent visibility from the cockpit, the aircraft could be maneuvered in confined areas on the ground with nosewheel steering, brakes, and engine power. Ground handling characteristics were above average. The power brakes were overly sensitive and tended to grab if applied too rapidly. Since the aircraft

could be backed up with the propellers in reverse mode, there was a danger of setting the tail on the ground if brakes were abruptly applied. A pilot of average ability, with a few minutes of practice, will be able to apply them effectively. Nevertheless, the sensitivity should be reduced. Ground steering was controlled by a steering handle located on the left side of the pilot compartment. Power control during taxi was effective whether on pavement or on hard-packed sand. Ease of handling was also helped by the oversized tires installed on the Skyvan.

Engine Operation

The difficulty of maintaining the exhaust gas temperature during takeoff and other high-power-output conditions was the one characteristic rated below the HQRS-2 level. Turbine inlet temperature is one of the most critical variables in engine operation. The exhaust gas temperature gauge is the primary indicator for the control of this temperature. The two side-by-side digital readout gauges, although satisfactory for indicating precise values, were difficult to read during moments of rapid temperature increase. Dial-pointer gauges, in this case, would be better suited to show temperature trend and rapidity of trend change, an important consideration when it is imperative that the operating temperature be kept at or below a maximum allowable value. This deficiency was rated as HQRS-5, defined as "moderately objectionable with considerable pilot compensation required for adequate performance."

Takeoff and Climb

Normal and short field takeoffs were performed in winds up to 25 knots, with gusts to 35 knots. Directional control during the takeoff roll was obtainable with rudder only. Adequate elevator and rudder control were available well before the selected rotation speed was reached. Pitch increase to climb attitude was normal, with elevator control forces acceptable. The extreme nose-up attitude encountered during maximum performance climbs reduced forward visibility and a straight-ahead view of the natural horizon. By looking 45° to the side, the pilot was able to see the horizon and the flight attitude was easily maintained.

Stability

Although some aspect of stability was a consideration in every flight-tested maneuver, the Skyvan was flown in a series of test patterns designed specifically to indicate the inherent static and dynamic stability of the airframe. The two most used flight configurations were cruise (flaps up, cruise power settings), and power approach (flaps extended, power settings to maintain a safe minimum airspeed). Pressure altitude was 9500 ft with air temperature at 18°C. The scope of the stability test is shown in the following table. Airspeeds are in knots indicated air speed (KIAS).

Type of Stability Tested	Configuration	Airspeed	Maneuver Used
Static-longitudinal	Cruise Power approach	150 70	Climbs and dives " " "
Static lateral-directional	Cruise Power approach	120 & 150 80	Left & right side slips " " " "
Short period oscillations	Cruise Power approach	160 70	Nose-up & nose-down stick pressures " " " "
Maneuvering	Cruise	Changing	Pull-ups and steady turns

Control forces and trim responses were normal for this type of aircraft. Stability was positive (control pressures were applied in the proper direction to execute the maneuver). Control force gradients were satisfactory (increases and decreases in pressures were in proper ratio to the amount of the maneuver desired). Longitudinal oscillations were deadbeat (nose-up or nose-down changes in level flight attitude, as imposed by the pilot, ceased as soon as he released the control, and the aircraft returned to level flight in one movement). Pilot cues (control pressure and movement feedback) were excellent and enhanced the pilot's ability to maintain precise control and to detect out-of-trim conditions.

Stalls

Cruise and power approach configurations at 7500-ft pressure altitude were also used in stall tests. From either configuration the stall was approached with a deceleration rate of one knot per second. In each case, the immediate result of the stall was a definite nose-down pitch and noticeable sink rate. Stall speed from the power approach was 40-45 KIAS. The aerodynamic warning was a delicate shaking of the control column - moderate enough to pass undetected when flying in light turbulence. The artificial stall-warning device provided both visual and aural signals that were adequate in signal strength. The warning came at 5-8 knots above stall. Controls were effective throughout the stall and recovery.

Trim Controls

Trim rates were satisfactory on all three axes, as were the trim forces with changes in aircraft configuration. Of particular interest was the effect on trim when the cargo door was opened during flight. At 140 KIAS the opening of the rear cargo door required an initial pull force of 6 lb on the elevator control. When the door became fully opened, the required pull force reduced to 3 lb. All trim characteristics tested were satisfactory for the Forest Service mission.

Single Engine Operation

Simulated engine failure tests were conducted at 6000-ft pressure altitude at 21°C. It took approximately 30 seconds to feather the dead engine. Single engine climb was at 90 KIAS and 490 ft per minute. Single engine slow flight was performed at 65 KIAS with full control.

Approach and Landing

Approach and landing characteristics were evaluated using normal, short field, and instrument techniques. Instant power response gave the pilot excellent control during short field approaches, which were flown at minimum safe airspeed and relatively high power settings. Control response on all three axes was excellent throughout the approach and touchdown. Reverse thrust was used on the short field landing with no tendency toward lag or uneven thrust reversal. The short field landing was accomplished in less than 1000 ft with a 25-knot headwind.

DISCUSSION

The Skyvan is an uncomplicated airplane when compared with many of the products of military and general aviation. Maintenance costs as well as initial cost are minimized by such design features as fixed landing gear, non-boosted flight controls, constant chord wing, and box-like fuselage construction. The pilot's job is made easier with power steering, power brakes, and reversible propellers. Power plants are modern, efficient and reliable. The rear opening cargo door provides a delivery system thoroughly proved in the field by the U.S. Army and U.S. Air Force. Since the Skyvan can carry 12 smokejumpers and cruise at 145 knots true airspeed, it should be included with other aircraft being considered as replacements for the DC-3 (see Appendix C, Performance Summary).

CONCLUSIONS

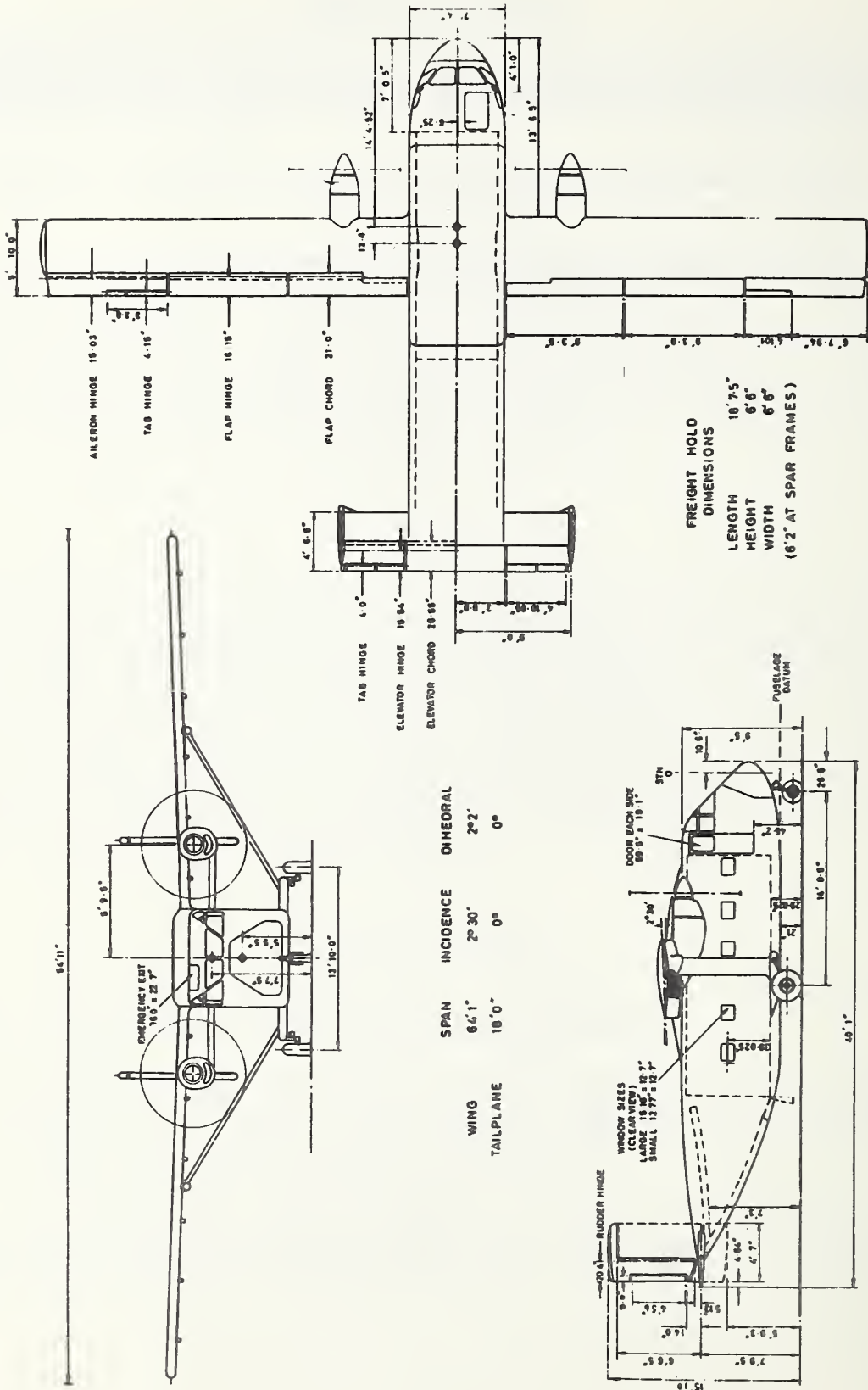
1. The handling qualities of the military version Skyvan, as tested at 12,000 lb gross weight and midpoint center of gravity, were satisfactory.
2. Performance characteristics were in general agreement with those listed in the manufacturer's publications. The aircraft meets performance requirements for Forest Service work, especially in those missions involving smokejumping, para-cargo, freight, and operations on unimproved airstrips.
3. Two shortcomings affecting efficiency of operation were the difficulty in maintaining exhaust gas temperature within limits during periods of high engine power output, and the oversensitive power brakes.

RECOMMENDATIONS

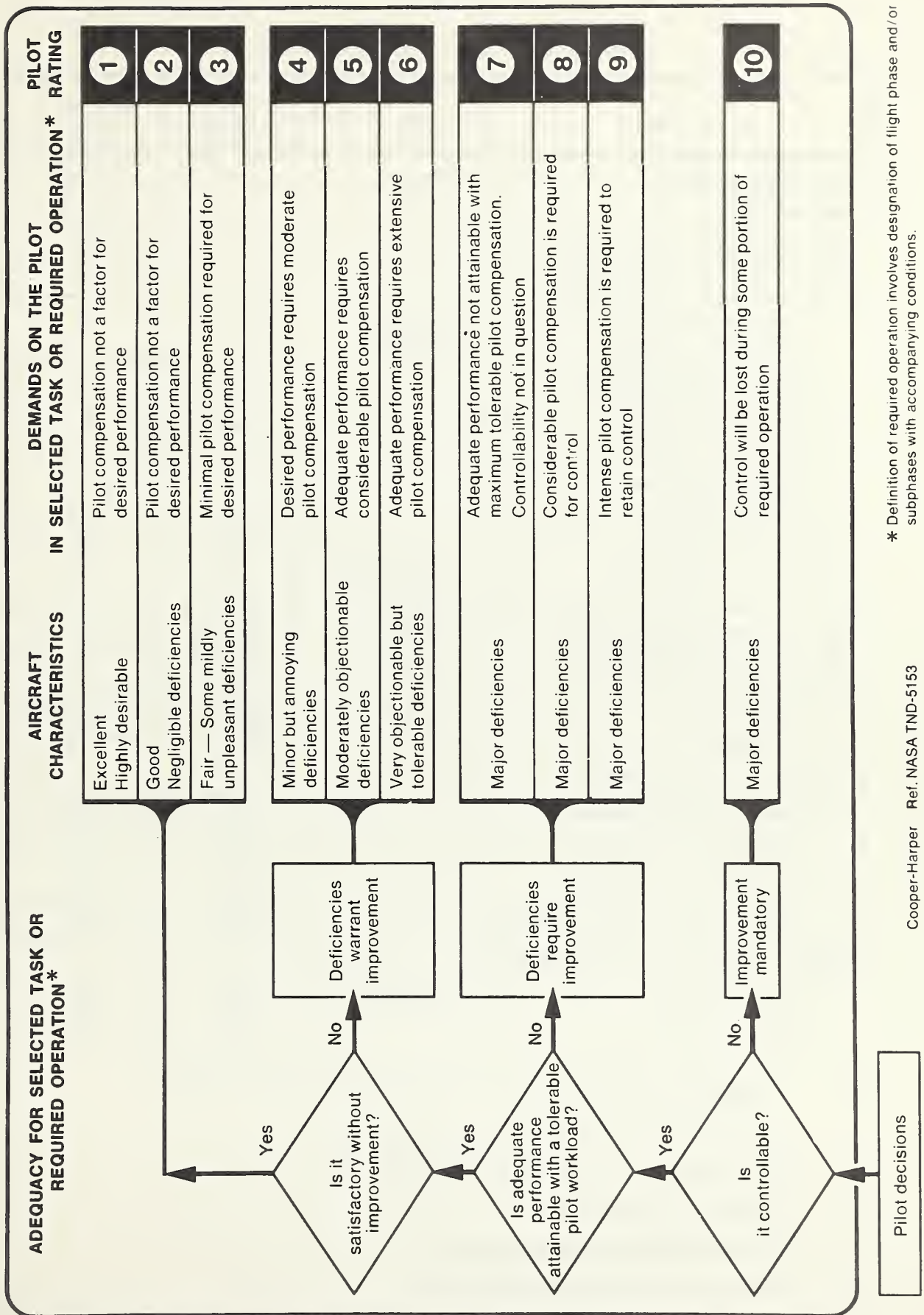
1. To complete the evaluation for mission suitability, test fly the Skyvan at 13,500 lb gross weight and with the center of gravity in its maximum allowable fore and aft positions.
2. Replace the digital-readout exhaust-gas-temperature gauges with gauges that use the dial pointer face.
3. Desensitize the power brakes for a more normal response.

APPENDIX A

EXTERIOR DIMENSIONS - SC7 MILITARY SKYVAN



HANDLING QUALITIES RATING SCALE



* Definition of required operation involves designation of flight phase and/or subphases with accompanying conditions.

APPENDIX C

PERFORMANCE SUMMARY SC7 MILITARY SKYVAN ^①

Test Conditions		Units	Flight Manual Values	Observed Flight Values ^②
Basic Operating Weight		Pounds	-	8,199 ^③
Maximum Payload		"	-	5,301 ^④
Maximum Takeoff and Landing Weight		"	-	13,500
Maximum Cruise Speed at 10,000 ft				
	Maximum Continuous Power at 100% RPM at 11,500 lb	Knots, true air speed	167	181
	Maximum Continuous Power at 100% RPM at 13,500 lb	"	162	176
	Maximum Cruise Power at 96% RPM at 11,500 lb	"	160	175
	Maximum Cruise Power at 96% at 13,500 lb	"	154	169
Cruise Speed at 10,000 ft		"	148	145
Stall Speed at 12,500 lb ^⑤		Knots, indicated air speed	60	57
Sea Level Rate of Climb at 13,500 lb		Ft per min.	1,350	1,375
Service Ceiling at 13,500 lb				
	Single-engine	Feet	8,000	Not determined
	Two-engine	"	18,500	18,500
Short Field Technique (13,500 lb)				
	Takeoff Ground Roll Distance	"	900	660
	Takeoff (over 50 ft obstacle)	"	1,325	1,000
	Landing Distance Ground Roll	"	740	935
	Landing Distance (over 50 ft obstacle)	"	1,400	1,720
Range - Maximum Fuel + 45 min reserve ^⑥				
	Payload, 3,000 lbs	Nautical miles	530	590
	Payload, 4,000 lbs	"	400	420

① Abstracted from USAF Report FTC-TR-69-34, "Flight Evaluation of Short SC7 Military Skyvan Series 3M".

② Data obtained from uncalibrated production instruments.

③ Test aircraft 15-passenger demonstration version.

④ 2,320 lb fuel included.

⑤ Values for aircraft in landing configuration.

⑥ Freighter version, operating weight 7,610 lb.

